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Relationship between the pore density in benthic foraminifera and bottom-water oxygen content

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Reliable estimates of bottom-water oxygen contents are crucial to understand the formation of past oxygen-depleted environments. Here, we investigate the relationship between pore density in calcareous benthic foraminiferal (BF) tests and measured oxygen concentrations of the surrounding bottom-waters (BW-O_2) in living (Rose Bengal stained) specimens of the shallow-infaunal species Bolivina pacifica, and the three deep-infaunal species Fursenkoina mexicana, Globobulimina turgida, and Chilostomella oolina. Used samples span a wide oxygen-gradient across oxygen minimum zones (OMZ) off Namibia and Pakistan.
Bolivina pacifica, F. mexicana and G. turgida display a significant negative exponential correlation between the pore density and BW-O_2, indicating a morphological response of the foraminifers to decreasing oxygenation. Supporting previous results, we suggest that an increasing number of pores improves the ability of oxygen uptake in low-oxygen environments. This morphological response can be used to establish an independent proxy for BW-O_2. The inter-specific comparison of the dependency of pore density and BW-O_2 reveals a steeper gradient for B. pacifica than for F. mexicana, and G. turgida. We hypothesize that the inter-specific pore density-BW-O_2-relationship may reflect their species-specific microhabitat preferences. The shallow-infaunal species B. pacifica is probably stronger affected by oxygen depletions than the two deep-infaunal species F. mexicana, and G. turgida. Our results for the deep-infaunal species C. oolina show no significant relationship between pore density and BW-O_2. This suggests that C. oolina has another life-strategy to survive sustained low-oxic conditions than increasing its pore density. Overall, we propose that the pore density of individual BF species provides a valuable independent proxy to reconstruct ancient bottom-water oxygenation.
To test the application of this proxy in fossil assemblages, we used the organic-carbon rich sapropel layer S1 in two cores from the North Agean Sea to illustrate the decrease in BW-O_2 before and during the sapropel formation as well as the BW-O_2 increase afterwards.